INDIANA MICHIGAN POWER An AEP Company	INDIANA MICHIGAN POWER D. C. COOK NUCLEAR PLANT UPDATED FINAL SAFETY ANALYSIS REPORT	Revised: 27.0 Table: 6.1-1 Page: 1 of 1

Net Positive Suction Heads for Post-DBA Operational Pumps

	Pump	Flow and Condition (per pump) gpm [1]	Suction Source	$NPSH_a$ (available minimum) ft_{abs}	$NPSH_r$ (required) ft_{abs}	Water Temp °F
1.	Safety Injection	678 max. flow	Refueling Water Storage Tank	45.4	31.8	105 max.
2.	Centrifugal Charging	530 max. flow	Refueling Water Storage Tank	39.8	17.6	105 max.
3.	Residual Heat Removal	4,175 max. flow	Recirculation Sump	26.3	17.1	190
4.	Containment Spray	3,406 max. flow	Recirculation Sump	27.8	14.9	190
5.	Component Cooling	11,200 max. flow	Closed Loop	37.1	25.5	160
6.	Essential Service Water	12,200 max. flow	Screenhouse (forebay at Elevation 562 ft.)	37.5	34.1	88.8

[1] NPSH values represent bounding conditions lowest NPSH margin for the most conservative operating conditions and component alignments analyzed of either unit.

SAFETY INJECTION SYSTEM CODE REQUIREMENTS[1]

Component	Code
Refueling Water Storage Tank	Not applicable
Residual Heat Exchanger	
Tube Side	ASME B&PV Code Section III Class C
Shell Side	ASME B&PV Code Section VIII
Accumulators	ASME B&PV Code Section III Class C
Valves	ANSI B16.5, MSS-SP-66, and ASME B&PV Code Section III, 1968 Edition [1]
Piping	USAS B31.1, 1967 Edition [1] ASME III Appendix F [2]
Boron Injection Tank	ASME B&PV Code Section III Class C
Recirculation Sump Strainers (Main and Remote)	AISC-69, 7th Edition
Debris Interceptors (CEQ Fan Room, Flood-Up Overflow Wall, and Entrance to Containment Wide Range Sump Level Instrument)	AISC-69, 7th Edition

[1] Repairs and replacements for pressure retaining components within the code boundary, and their supports, are conducted in accordance with ASME Section XI.

[2] The evaluation criteria of ASME III Appendix F (faulted conditions) is applicable to accumulator fill line piping from outside containment isolation valve to the normally closed inlet valves at each accumulator and the normally closed valves in the flow path to the low head SI hot leg loops (CPN 32).

ACCUMULATOR DESIGN PARAMETERS

Number	4 per unit
Type	Stainless steel clad / carbon steel
Design pressure, psig	700
Design temperature, ºF	300
Operating temperature, ºF	120
Normal pressure, psig	621.5
Minimum pressure, psig	585.0
Total volume, ft^3	1350
Maximum water volume at operating conditions, ft^3	971
Minimum water volume at operating conditions, ft^3	921
Boron concentration (as boric acid), ppm	2400 to 2600
Code	ASME B&PV Code Section III Class C

BORON INJECTION TANK DESIGN PARAMETERS

Number	1 per unit
Total Volume, gal (also useable volume)	900
Boron concentration, (ppm)	0 to 2600
Design pressure, psig	2735
Design temperature, ºF	300
Operating pressure, psig (Injection Mode)	2340
Operating pressure, psig (Standby)	atmospheric
Operating temperature, ºF	ambient
Material	SS Clad Carbon Steel
Code	ASME B&PV Code Section III Class C

REFUELING WATER STORAGE TANK DESIGN PARAMETERS

Number	1 per unit
Tank Capacity, gal.	420,000
Required Capacity, gal.	375,500
Design pressure, psig	Static head and sloshing
Design temperature, ºF	-30 to 100
Normal pressure, psig	Atmospheric
Liquid temperature,º F	70 - 100
Inside diameter, ft (approx.)	48
Straight side height, ft	31
Material	Stainless Steel

DESIGN PARAMETERS – ECCS PUMPS

	Centrifugal Charging Pumps	Safety Injection Pumps	Residual Heat Removal Pumps
Number per unit	2	2	2
Design pressure, psig	2800	1700	600
Design temperature, °F	300	300	400
Design flow rate, gpm	150	400	3000
Design head, ft.	5800	2500	350
Max. flow rate, gpm	550	700[1]	4500
Head at max. flow rate, ft.	1400	1500	300
Motor horsepower	600	400	400
Pump Speed, rpm	4810[2]	3570	1780
Type	Horizontal Multistage Centrifugal	Horizontal Multistage Centrifugal	Vertical, in-line Single stage Centrifugal
Material	Stainless Steel or Stainless Steel clad Carbon steel	Stainless Steel	Stainless Steel

The motor starting times from electrical activation to full speed (steady- state-voltage) as obtained by a computer simulation are as follows:

Centrifugal Charging Pump	1.14 seconds
Safety Injection Pump	1.13 seconds
Residual Heat Removal Pump	0.704 seconds

[1] Maximum flow rate is limited to 675 gpm for pumps that have not been qualified to a higher flow rate, up to a maximum of 700 gpm.

[2] Equipped with speed increaser gear.

SINGLE ACTIVE FAILURE ANALYSIS EMERGENCY CORE COOLING SYSTEM RECIRCULATION PHASE

Component	Malfunction	Comments
A. Accumulator	Deliver to broken loop	Totally passive system with one accumulator per loop. Evaluation based on three accumulators delivering to the core and one spilling from ruptured loop.
B. Pump:		
1) Centrifugal Charging	Fails to start	Two provided. Evaluation based on operation of one.
2) Safety Injection	Fails to start	Two provided. Evaluation based on operation of one.
3) Residual Heat Removal	Fails to start	Two provided. Evaluation based on operation of one.
C. Automatically Operated Valves:		
1) Boron injection tank isolation		
a) inlet valve	Fails to open	Two parallel lines; one valve in either line is required to open.
b) outlet valve	Fails to open	Two parallel lines; one valve in either line is required to open.
2) Centrifugal Charging pumps		
a) suction line from RWST isolation valve	Fails to open	Two parallel lines; only one valve in either line is required to open.
b) discharge line to the normal charging path isolation valve[1]	Fails to close	Two valves in series; only one valve required to close.
c) minimum flow line isolation valve	Fails to close	Two trains in parallel; only one train required.
d) suction from volume control tank isolation valve	Fails to close	Two valves in series; only one valve required to close.

[1] The reactor coolant pump seal water path is left open.

SINGLE ACTIVE FAILURE ANALYSIS EMERGENCY CORE COOLING SYSTEM RECIRCULATION PHASE

Component	Malfunction	Comments
Recirculation Phase		
A. Valves operated From Control Room for Recirculation:		
1) Containment sump recirculation isolation	Fails to open	Two lines parallel; only one valve in either line is required to open.
2) Residual heat removal pumps suction line from RWST isolation	Fails to close	Check valve in series with two gate valves; operation of only one valve required.
3) Safety injection pumps suction line from RWST	Fails to close	Check valve in series with gate valve; operation of only one valve required.
4) Centrifugal Charging pumps suction line from RWST isolation valve	Fails to close	Check valve in series with two parallel gate valves. Operating of either the check valve or the gate valves required.
5) Safety injection pump suction line isolation valve at discharge of the west residual heat exchanger	Fails to open	Separate and independent high head injection path via the centrifugal charging pumps taking suction from discharge of the East residual heat residual head exchanger. A cross over line allows the flow from one heat exchanger to reach both safety injection and charging pumps if necessary.
6) Residual Heat Removal discharge bypass line	Fails to close	The second isolation valve for RWST backflow is still available.

SINGLE ACTIVE FAILURE ANALYSIS EMERGENCY CORE COOLING SYSTEM RECIRCULATION PHASE

Component	Malfunction	Comments
B. Pumps:		
1) Component Cooling Water Pump	Fails to start	Two provided. Evaluation based on operation of one. One pump is running during normal operation. An additional shared pump is available.
2) Essential Service Water Pump	Fails to start	Four provided for both units. Two pumps are required for normal operation.
3) Residual Heat Removal Pump	Fails to start	Two provided. Evaluation based on operation of one.
4) Charging Pump	Fails to operate	Same as injection phase.
5) Safety Injection Pumps	Fails to operate	Same as injection phase.

SINGLE PASSIVE FAILURE ANALYSIS – EMERGENCY CORE COOLING SYSTEM

RECIRCULATION PHASE

Flow Path	Indication of Loss of Flow Path	Alternate Flow Path
COLD LEG		
From containment recirculation sump to low head cold leg injection header via the residual heat removal pumps and the residual heat exchangers.	Reduced flow in the discharge line, from one of the residual heat exchangers (one flow monitor in each discharge line) and/or leakage sump level alarm	Via the independent identical low head flow path utilizing the pumps second residual heat exchanger
HOT LEG		
From containment recirculation sump to hot leg low – head injection header via RHR pumps and RHR heat exchangers.	Same as above	Same as above
COLD LEG		
From containment recirculation sump to the high head cold leg injection header via the west residual heat removal pump, west residual heat exchanger and the safety injection pumps.	Reduced flow in the discharge lines from the safety injection pumps (one flow monitor in each discharge line) and/or leakage sump level alarm.	From containment recirculation sump to the high head cold leg injection headers via east residual heat removal pump, east residual heat exchanger and the centrifugal charging pumps cross - tie to SI pump suction.
HOT LEG		
From containment recirculation sump to the high head hot leg injection headers via west residual removal pump, west residual heat exchanger and the safety injection pumps.	Reduced flow in the discharge lines from the safety injection pumps (one flow monitor in each discharge line) and/or leakage sump level alarm.	From containment spray to the high head hot leg injection points via East residual heat removal heat removal pump, East residual heat exchanger and the centrifugal charging pumps cross tie to SI Pump suction

ACCUMULATOR INLEAKAGE

OBSERVED LEAK RATE CC/HR	TIME PERIOD BETWEEN LEVEL ADJUSTMENTS (BETWEEN LEVEL ALARM) [1, 2]		(OBSERVED LEAK RATE) DIVIDED BY (MAX ALLOWED DESIGN) [3]
	MAXIMUM	ANTICIPATED	
1538	1 month	16 days	77
513	3 months	7 weeks	25.7
256	6 months	13 weeks	12.8
171	9 months	20 weeks	8.6
128	1 year	27 weeks	6.4

[1] 25.0 cu. ft. between level alarms.
[2] Accumulator initially at "Lo" level and pressure conditions.
[3] Maximum allowed leak rate for manufacturer's acceptance test is 20 cc/hr (Back Leakage through check valves).

RECIRCULATION LOOP LEAKAGE

Items	No. of Units	Type of Leakage Control and Unit Leakage Rate Used in the Original Analysis[1]	Leakage to Atmosphere cc/hr	Leakage to Drain Tank cc/hr
1. Residual Heat Removal Pumps (Low Head Safety Injection)	2	Mechanical seal with leakoff - 1 drop/min	0	6
2. Centrifugal Charging Pump	2	Same as residual heat removal pump	0	6
3. Safety Injection Pump	2	Same as residual heat removal pump	0	6
4. Flanges:		Gasket adjusted to zero leakage following any test 10 drops/min/flange used in analysis		
a. Pump	8		240	0
b. Valves Bonnet Body (larger than 2")	40		1200	0
c. Control Valves	6		180	0
5. Valves Stem Leakoffs	40	Back-seated, double packing with leakoff 1 cc/hr/in. stem diameter	0	40
6. Misc. Small Valves	50	Flanged body packed stems - 1 drop/min used	150	0
		TOTALS	1770	58

[1] License amendments 49 (Unit 1) and 34 (Unit 2) require implementation of a program to reduce leakage from systems outside containment that would or could contain highly radioactive fluids during a serious transient or accident to as low as practical levels. This table is retained as part of the original FSAR and is not intended to be updated. The original FSAR assumed approximately 1770 cc/hr ECCS leakage and 2806 cc/hr CTS leakage for a total of approximately 4576 cc/hr total ESF leakage. See Section 14.3.5.19 and Section 14.3.5.20.4 for current information.

RECIRCULATION SUMP COMPONENT DESIGN LOAD COMBINATIONS[1]

Load Combination Case No.	Description	Load Combination
0	Full Recirculation Flow with Clean Main and Remote Strainers; Applicable to Main and Remote Strainers	DW[2] + TAL[3] + DBE[4] + FRHL[5] + DL[6] + NL(t)[7]
1	Loads Immediately after the Pipe Rupture; Applicable to Main and Remote Strainers	DW(2) + TBL[8] + DBE(4) + NL(t)(7)
2	Containment Fill; Forward Flow through Main Strainer with Reverse Flow through Waterway to Remote Strainer	DW(2) + TFL[9] + DBE(4) + NL(t)(7) + PFHL[10]
3	Plugged Main Strainer with Recirculation Flow from Remote Strainer	DW(2) + TAL(3) + DBE(4) + FRHL(5) + DL(6) + NL(t)(7)
4	Pressure Pulse at Instant of Pipe Rupture; Applicable to Main and Remote Strainers	DW(2) + TOL[11] + PP[12] + NL(t)(7)

[1] The load combinations are used for the design and qualification of the main and remote strainers and waterway, unless otherwise indicated in the Description column.
[2] DW - Dead Weight.
[3] TAL - Thermal effects at accident temperature of 160°F when recirculation is initiated for a large break LOCA consistent with the time of maximum hydrodynamic load.
[4] DBE - Design Basis Earthquake.
[5] FRHL - Full Recirculation Hydraulic Loads at 14,400 gpm, the bounding value for ECCS flow
[6] DL - Debris Load. For structural analysis of main and remote strainers, bounding debris mass values of 1986 lbs and 1530 lbs, respectively, were used.
[7] NL(t) - Nozzle Loads. Loads applicable only to the remote strainer and local conditions at the time of the load case.
[8] TBL - Thermal Break Load. Thermal effects at post-break containment environment temperature of 236°F.
[9] TFL - Thermal Fill Loads During Pool Fill (200°F).
[10] PFHL - Pool Fill Hydraulic Loads – reverse flow and waterway loads.
[11] TOL – Thermal effects at normal (maximum) operating temperature of 160°F for the main strainer and 120°F for the remote strainer.
[12] PP - Pressure Pulse. Short term pressure pulse of 5.0 psid acting outward from within the main strainer and waterway and 2.5 psid acting outward from within the interface between the waterway and the remote strainer.

CONTAINMENT SPRAY PUMP DESIGN PARAMETERS

Quantity	2 (per unit)
Type	Vertical, centrifugal
Design Pressure	600 psig
Design Temperature	400 ^{o}F
Design flow rate	3200 gpm
Design head	490 ft.
Motor horsepower	600 hp.
Motor speed	1780 rpm

Containment Spray Heat Exchanger Design Parameters

Heat Exchanger		**Heat Exchanger**
Quantity, Unit 1 / Unit 2		2 (1-HE-18E / W) / 2 (2-HE-18E / W)
Type		Vertical / Shell and U Tube
Heat Transfer per unit (Btu / hr)		114.2×10^6
Flow, tube side, gpm		2942
Flow, shell side, gpm		2400
Shell side inlet temperature, ºF		90
Tube side inlet temperature, ºF		164
Shell side outlet temperature, ºF		137.87
Tube side outlet temperature, ºF		124.20
Material Shell / Tube		Carbon Steel / SS
Design Pressure, Shell / Tube psig		150 / 300
Design Temperature, Shell / Tube, ºF		200 / 200

Containment Spray Heat Exchanger Code Requirements

Shell Side	ASME 1968 B&PV Code Section VIII Div. 1
Tube Side	ASME 1968 B&PV Code Section III Class C

SPRAY ADDITIVE TANK DESIGN PARAMETERS

Quantity	1 (per unit)
Volume, gal	5218
Design temperature, °F	200
Design pressure, psig	10
Material	stainless steel

SPRAY ADDITIVE TANK CODE REQUIREMENTS

ASME 1968 B&PV Section VIII Div. 1

Containment Spray System Malfunction Analysis

Component	Malfunction	Comments and Consequences
1. Containment Spray Pump	Rupture of Pump casing	Isolate train. Redundant train continues to operate reqi rement is one train.
2. Containment Spray Pump	Pump fails to start.	One of two pumps operating will supply 100 percent of reqi red flow
3. Containment Spray Pump	Pump suction line closed	This is prevented by pre startup checks. During power operation, each pump is tested on a periodic basis. During these tests checks will be made to confirm that a motor operated valve (from the refueling water storage tank) is open. The manual valve from the recirculation sump is locked or sealed open. Motor operated valve positions (open or closed) are indicated in the control room
4. Containment Spray Pump	Pump discharge motor operated valve fails to open.	Motor operated valves are redundant and only one of the two need operate. Valve positions (open or closed) are indicated in the control room.
5. Containment Spray Pump	Discharge Check Valve fails to open	The check valves were checked in preoperational tests and are checked during periodic tests.
6. Containment Spray Heat Exchanger	Drain Valve left open / Manways left open	This is prevented by pre-startup checks. Leak detection sumps in the spray system compartments are provided with level alarms which are initiated if a drain valve is open and discharging into the compartment

Containment Spray System Malfunction Analysis

Component	Malfunction	Comments and Consequences
7. Containment Spray Heat Exchangers	Tube or shell rupture	Isolate train. Redundant train continues to operate. One train will provide 100% flow.
8. Containment Spray Eductors	Motor Operated Supply Valve fails to open	The motive water supply valve is normally open and is checked by periodic test.
		The suction supply valves (from the spray additive tank) are redundant and only one of the two need be open. Valve position is indicated in the Control Room.